NOx Control Cost Effectiveness Estimate

Engine Manufacturer	General Electric
Model No.	LM 1600
Unit ID	12A
Fuel Used	Natural Gas
Emissions Control	SCR
Combustion Control Purpose	NOx
Target Reduction	75%

Color Legend

User Data / Information Input Cell
"Cumulative" Cost Cell for Primary Categories
Cost Effectiveness ($ / ton)

1 Engine Design Conditions

			Comments
Power Output	19200	(hp)	Rated HP
Engine Exhaust Temperature		(F)	*optional input*
Engine Exhaust Rate		(lb/hr)	*optional input*
Gas Volume		(dscfm)	*optional input*

2 Full Load Engine Exhaust Composition:

			Comments
Oxygen (O_2)		(vol. %)	*optional input*
Carbon Dioxide (CO_2)		(vol. %)	*optional input*
Water (H_2O)		(vol. %)	*optional input*
Oxides of Nitrogen (NOx)		(ppmvd)	*optional input*
Nitrogen (N_2)		(vol. %)	*optional input*
NOx	52.7 lb/hr	0.366 (lb/MMBtu)	NOx emissions from test Data: 373.0 lb/MMSCF ~0.37 lb/MMBtu

3 Engine Parameters

				Comments
Total Operating Hours per Season	8760	(hrs)	100% utilization	

4 Final Exhaust Gas Composition

			Comments
Oxides of Nitrogen (NOx)	13.2 lb/hr	0.092 (lb/MMBtu)	Assume 75% reduction

5 Economic Parameters

			Comments
Source of Cost Data	see Analysis		Analysis primarily relying on EPA Cost Manual

Direct Costs		**Cost Formula**	**Comments**
Combustion Control Equipment and Auxiliary Equipment	$3,712,500	(A)	Based on EPA control cost manual ($167/kw; adjust to 2020$)
Instrumentation	$371,250	(0.1*A)	Calculated Cost using EPA Control Cost Manual
Sales Taxes	$0	(0.03*(A+instrumentation))	No Oregon sales tax
Freight	$185,625	(0.05*A)	Calculated Cost using EPA Control Cost Manual
Purchased Equipment Cost (PEC)	**$4,269,375**	PEC	

6 Direct Installation Costs

		Cost Formula	**Comments**
Foundations and Supports	$341,550	(0.08*PEC)	Calculated Cost using EPA Control Cost Manual
Handling and Erection	$597,710	(0.14*PEC)	Calculated Cost using EPA Control Cost Manual
Electrical	$170,780	(0.04*PEC)	Calculated Cost using EPA Control Cost Manual
Piping	$85,390	(0.02*PEC)	Calculated Cost using EPA Control Cost Manual
Insulation for ductwork	$42,690	(0.01*PEC)	Calculated Cost using EPA Control Cost Manual
Painting	$42,690	(0.01*PEC)	Calculated Cost using EPA Control Cost Manual
Site Preparation	$0	SP	Cost included with next row
Buildings	$235,000	Bldg	Quote for piping rerouting, etc. to accommodate retrofit
Total Installation Cost (TIC)	**$1,515,810**		
Total Direct Costs (PEC+TIC)	**$5,785,185**		

7 Indirect Costs

		Cost Formula	**Comments**
Engineering	$426,938	(0.10*PEC)	Calculated Cost using EPA Control Cost Manual
Construction and field expenses	$213,469	(0.05*PEC)	Calculated Cost using EPA Control Cost Manual
Contractor fees	$426,938	(0.10*PEC)	Calculated Cost using EPA Control Cost Manual
Start-up	$85,388	(0.02*PEC)	Calculated Cost using EPA Control Cost Manual
Performance test	$42,694	(0.01*PEC)	Calculated Cost using EPA Control Cost Manual
Contingencies	$128,081	(0.03*PEC)	Calculated Cost using EPA Control Cost Manual
Total Indirect Costs (IC)	**$1,323,506**	(0.31*PEC)	

8 Capital Cost Summary

		Comments
Total Direct Capital Costs (DC)	$5,785,185	
Total Indirect Capital Costs (IC)	$1,323,506	
Total Capital Investment (TCI)	**$7,108,691**	

9 Direct Annual Costs

		Cost Formula	**Comments**
Operator Labor	$26,000	nominal cost	5 hours per week (1 hr x 5 days); job category labor rate
Supervisor Labor	$3,900		15% of operator
Operating Materials - ammonia	$54,289		materials estimate annual NH3 at $700 per ton; 1.1 molar ratio
Maintenance - Labor	$26,000	nominal cost	5 hours per week (1 hr x 5 days); job category labor rate
Maintenance - Materials	$5,000	nominal cost	Engineering Estimate
Catalyst maintenance / replacement	$185,625		Engineering Estimate (5% of Cap Cost)
Testing and QA/QC	$20,000		Engineering estimate - Annual test; reagent controller QA
Electricity	$2,500		Estimate based on analysis in PA DEP TSD
Total Direct Annual Costs	**$323,314**		

10 Indirect Annual Costs

		Cost Formula	**Capital Recovery Factor**	**Comments**
Overhead	$36,540	(0.6*(OL+SL+ML+MM))		
Administrative Charges	$142,174	(0.02*TCI)		Engine ACT Document
Property Taxes	$71,087	(0.01*TCI)		Engine ACT Document
Insurance	$71,087	(0.01*TCI)	**CRF**	
Capital Recovery	$374,628	CRF[TCI]	0.0527	Factor for costs annualized over 30 years at 3.25% interest.
Total Indirect Annual Costs	**$695,516**			CRF = i * (1+i)^n / [(1+i)^n - 1] (i expressed as a decimal - e.g., 10% = 0.1)

11 Summary

			Comments
Total Direct Annual Operating Costs	$323,314		
Total Indirect Annual Operating Costs	$695,516		
Total Annual Costs	$1,018,830	$53 $ per hp	
Incremental Annual Costs Over Baseline	$1,018,830		

12 Annual Emissions Reduction Over Baseline

		Comments
Oxides of Nitrogen (NOx)	173.13 (Tons)	

Cost Effectiveness ($/Ton)			**Comments**
Oxides of Nitrogen (NOx)	$5,885		PSEL basis: significantly over-estimates utilization
	$11,456	at 50% utilization (4,380 hours annually)	
	$27,933	at 2017-2019 average utilization (20.2%)	
	$13,422	at 2028 projected utilization (42.5%)	

NOx Control Cost Effectiveness Estimate

Engine Manufacturer	Cooper-Rolls
Model No.	Avon
Unit ID	12B
Fuel Used	Natural Gas
Emissions Control	SCR
Combustion Control Purpose	NOx
Target Reduction	75%

Color Legend

User Data / Information Input Cell
"Cumulative" Cost Cell for Primary Categories
Cost Effectiveness ($ / ton)

1 Engine Design Conditions

			Comments
Power Output	14300	(hp)	Rated HP
Engine Exhaust Temperature		(F)	*optional input*
Engine Exhaust Rate		(lb/hr)	*optional input*
Gas Volume		(dscfm)	*optional input*

2 Full Load Engine Exhaust Composition:

			Comments
Oxygen (O_2)		(vol. %)	*optional input*
Carbon Dioxide (CO_2)		(vol. %)	*optional input*
Water (H_2O)		(vol. %)	*optional input*
Oxides of Nitrogen (NOx)		(ppmvd)	*optional input*
Nitrogen (N_2)		(vol. %)	*optional input*
NOx	23.1 lb/hr	0.170 (lb/MMBtu)	NOx emissions from test Data: 173.9 lb/MMSCF ~0.170 lb/MMBtu

3 Engine Parameters

				Comments
Total Operating Hours per Season	8760	(hrs)	100% utilization	

4 Final Exhaust Gas Composition

			Comments
Oxides of Nitrogen (NOx)	5.8 lb/hr	0.043 (lb/MMBtu)	Assume 75% reduction

5 Economic Parameters

			Comments
Source of Cost Data	see Analysis		Analysis primarily relying on EPA Cost Manual

Direct Costs		**Cost Formula**	**Comments**
Combustion Control Equipment and Auxiliary Equipment	$2,765,000	(A)	Based on EPA control cost manual ($167/kw; adjust to 2020$)
Instrumentation	$276,500	(0.1*A)	Calculated Cost using EPA Control Cost Manual
Sales Taxes	$0	(0.03*(A+instrumentation))	No Oregon sales tax
Freight	$138,250	(0.05*A)	Calculated Cost using EPA Control Cost Manual
Purchased Equipment Cost (PEC)	**$3,179,750**	PEC	

6 Direct Installation Costs

		Cost Formula	**Comments**
Foundations and Supports	$254,380	(0.08*PEC)	Calculated Cost using EPA Control Cost Manual
Handling and Erection	$445,170	(0.14*PEC)	Calculated Cost using EPA Control Cost Manual
Electrical	$127,190	(0.04*PEC)	Calculated Cost using EPA Control Cost Manual
Piping	$63,600	(0.02*PEC)	Calculated Cost using EPA Control Cost Manual
Insulation for ductwork	$31,800	(0.01*PEC)	Calculated Cost using EPA Control Cost Manual
Painting	$31,800	(0.01*PEC)	Calculated Cost using EPA Control Cost Manual
Site Preparation	$0	SP	Cost included with next row
Buildings	$1,035,000	Bldg	Quote for major reconstruction to accommodate retrofit
Total Installation Cost (TIC)	**$1,988,940**		
Total Direct Costs (PEC+TIC)	**$5,168,690**		

7 Indirect Costs

		Cost Formula	**Comments**
Engineering	$317,975	(0.10*PEC)	Calculated Cost using EPA Control Cost Manual
Construction and field expenses	$158,988	(0.05*PEC)	Calculated Cost using EPA Control Cost Manual
Contractor fees	$317,975	(0.10*PEC)	Calculated Cost using EPA Control Cost Manual
Start-up	$63,595	(0.02*PEC)	Calculated Cost using EPA Control Cost Manual
Performance test	$31,798	(0.01*PEC)	Calculated Cost using EPA Control Cost Manual
Contingencies	$95,393	(0.03*PEC)	Calculated Cost using EPA Control Cost Manual
Total Indirect Costs (IC)	**$985,723**	(0.31*PEC)	

8 Capital Cost Summary

		Comments
Total Direct Capital Costs (DC)	$5,168,690	
Total Indirect Capital Costs (IC)	$985,723	
Total Capital Investment (TCI)	**$6,154,413**	

9 Direct Annual Costs

		Cost Formula	**Comments**
Operator Labor	$26,000	nominal cost	5 hours per week (1 hr x 5 days); job category labor rate
Supervisor Labor	$3,900		15% of operator
Operating Materials - ammonia	$23,789		materials estimate annual NH3 at $700 per ton; 1.1 molar ratio
Maintenance - Labor	$26,000	nominal cost	5 hours per week (1 hr x 5 days); job category labor rate
Maintenance - Materials	$5,000	nominal cost	Engineering Estimate
Catalyst maintenance / replacement	$138,250		Engineering Estimate (5% of Cap Cost)
Testing and QA/QC	$20,000		Engineering estimate - Annual test; reagent controller QA
Electricity	$2,500		Estimate based on analysis in PA DEP TSD
Total Direct Annual Costs	**$245,439**		

10 Indirect Annual Costs

		Cost Formula	**Capital Recovery Factor**	**Comments**
Overhead	$36,540	(0.6*(OL+SL+ML+MM))		
Administrative Charges	$123,088	(0.02*TCI)		Engine ACT Document
Property Taxes	$61,544	(0.01*TCI)		Engine ACT Document
Insurance	$61,544	(0.01*TCI)	**CRF**	
Capital Recovery	$324,338	CRF[TCI]	0.0527	Factor for costs annualized over 30 years at 3.25% interest.
Total Indirect Annual Costs	**$607,054**			CRF = i * (1+i)^n / [(1+i)^n - 1] (i expressed as a decimal - e.g., 10% = 0.1)

11 Summary

			Comments
Total Direct Annual Operating Costs	$245,439		
Total Indirect Annual Operating Costs	$607,054		
Total Annual Costs	$852,493	$60 $ per hp	
Incremental Annual Costs Over Baseline	$852,493		

12 Annual Emissions Reduction Over Baseline

		Comments
Oxides of Nitrogen (NOx)	75.87 (Tons)	

Cost Effectiveness ($/Ton)

			Comments
Oxides of Nitrogen (NOx) - $ per ton	$11,237		PSEL basis: significantly over-estimates utilization
	$50,889	at 2017-2019 average utilization (21.6%)	
	$26,016	at 2028 projected utilization (42.5%)	

NOx Control Cost Effectiveness Estimate

Engine Manufacturer	Solar
Model No.	Titan
Unit ID	12C
Fuel Used	Natural Gas
Emissions Control	SCR
Combustion Control Purpose	NOx
Target Reduction	60%

Color Legend

User Data / Information Input Cell
"Cumulative" Cost Cell for Primary Categories
Cost Effectiveness ($ / ton)

1 Engine Design Conditions

			Comments
Power Output	19500	(hp)	Rated HP
Engine Exhaust Temperature		(F)	*optional input*
Engine Exhaust Rate		(lb/hr)	*optional input*
Gas Volume		(dscfm)	*optional input*

2 Full Load Engine Exhaust Composition:

			Comments
Oxygen (O_2)		(vol. %)	*optional input*
Carbon Dioxide (CO_2)		(vol. %)	*optional input*
Water (H_2O)		(vol. %)	*optional input*
Oxides of Nitrogen (NOx)		(ppmvd)	*optional input*
Nitrogen (N_2)		(vol. %)	*optional input*
NOx	6.8 lb/hr	0.052 (lb/MMBtu)	NOx emissions from test Data: 52.6 lb/MMSCF ~0.052 lb/MMBtu

3 Engine Parameters

				Comments
Total Operating Hours per Season	8760	(hrs)	100% utilization	

4 Final Exhaust Gas Composition

			Comments
Oxides of Nitrogen (NOx)	2.7 lb/hr	0.021 (lb/MMBtu)	Assume 60% reduction for unit equipped with DLE combustion

5 Economic Parameters

			Comments
Source of Cost Data	see Analysis		Analysis primarily relying on EPA Cost Manual

Direct Costs		**Cost Formula**	**Comments**
Combustion Control Equipment and Auxiliary Equipment	$3,770,500	(A)	Based on EPA control cost manual ($167/kw; adjust to 2020$)
Instrumentation	$377,050	(0.1*A)	Calculated Cost using EPA Control Cost Manual
Sales Taxes	$0	(0.03*(A+instrumentation))	No Oregon sales tax
Freight	$188,525	(0.05*A)	Calculated Cost using EPA Control Cost Manual
Purchased Equipment Cost (PEC)	**$4,336,075**	PEC	

6 Direct Installation Costs

		Cost Formula	**Comments**
Foundations and Supports	$346,890	(0.08*PEC)	Calculated Cost using EPA Control Cost Manual
Handling and Erection	$607,050	(0.14*PEC)	Calculated Cost using EPA Control Cost Manual
Electrical	$173,440	(0.04*PEC)	Calculated Cost using EPA Control Cost Manual
Piping	$86,720	(0.02*PEC)	Calculated Cost using EPA Control Cost Manual
Insulation for ductwork	$43,360	(0.01*PEC)	Calculated Cost using EPA Control Cost Manual
Painting	$43,360	(0.01*PEC)	Calculated Cost using EPA Control Cost Manual
Site Preparation	$0	SP	As required
Buildings	$0	Bldg	Not considered (initial iteration - $ per ton are high for this unit)
Total Installation Cost (TIC)	**$1,300,820**		
Total Direct Costs (PEC+TIC)	**$5,636,895**		

7 Indirect Costs

		Cost Formula	**Comments**
Engineering	$433,608	(0.10*PEC)	Calculated Cost using EPA Control Cost Manual
Construction and field expenses	$216,804	(0.05*PEC)	Calculated Cost using EPA Control Cost Manual
Contractor fees	$433,608	(0.10*PEC)	Calculated Cost using EPA Control Cost Manual
Start-up	$86,722	(0.02*PEC)	Calculated Cost using EPA Control Cost Manual
Performance test	$43,361	(0.01*PEC)	Calculated Cost using EPA Control Cost Manual
Contingencies	$130,082	(0.03*PEC)	Calculated Cost using EPA Control Cost Manual
Total Indirect Costs (IC)	**$1,344,183**	(0.31*PEC)	

8 Capital Cost Summary

		Comments
Total Direct Capital Costs (DC)	$5,636,895	
Total Indirect Capital Costs (IC)	$1,344,183	
Total Capital Investment (TCI)	**$6,981,078**	

9 Direct Annual Costs

		Cost Formula	**Comments**
Operator Labor	$26,000	nominal cost	5 hours per week (1 hr x 5 days); job category labor rate
Supervisor Labor	$3,900		15% of operator
Operating Materials - ammonia	$7,045		materials estimate annual NH3 at $700 per ton; 1.1 molar ratio
Maintenance - Labor	$26,000	nominal cost	5 hours per week (1 hr x 5 days); job category labor rate
Maintenance - Materials	$5,000	nominal cost	Engineering Estimate
Catalyst maintenance / replacement	$188,525		Engineering Estimate (5% of Cap Cost)
Testing and QA/QC	$20,000		Engineering estimate - Annual test; reagent controller QA
Electricity	$2,500		Estimate based on analysis in PA DEP TSD
Total Direct Annual Costs	**$278,970**		

10 Indirect Annual Costs

		Cost Formula	**Capital Recovery Factor**	**Comments**
Overhead	$36,540	(0.6*(OL+SL+ML+MM))		
Administrative Charges	$139,622	(0.02*TCI)		Engine ACT Document
Property Taxes	$69,811	(0.01*TCI)		Engine ACT Document
Insurance	$69,811	(0.01*TCI)	**CRF**	
Capital Recovery	$367,903	CRF[TCI]	0.0527	Factor for costs annualized over 30 years at 3.25% interest.
Total Indirect Annual Costs	**$683,686**			CRF = i * (1+i)^n / [(1+i)^n - 1] (i expressed as a decimal - e.g., 10% = 0.1)

11 Summary

			Comments
Total Direct Annual Operating Costs	$278,970		
Total Indirect Annual Operating Costs	$683,686		
Total Annual Costs	$962,656	$49 $ per hp	
Incremental Annual Costs Over Baseline	$962,656		

12 Annual Emissions Reduction Over Baseline

		Comments
Oxides of Nitrogen (NOx)	17.97 (Tons)	

Cost Effectiveness ($/Ton)

		Comments
Oxides of Nitrogen (NOx)	$53,559	